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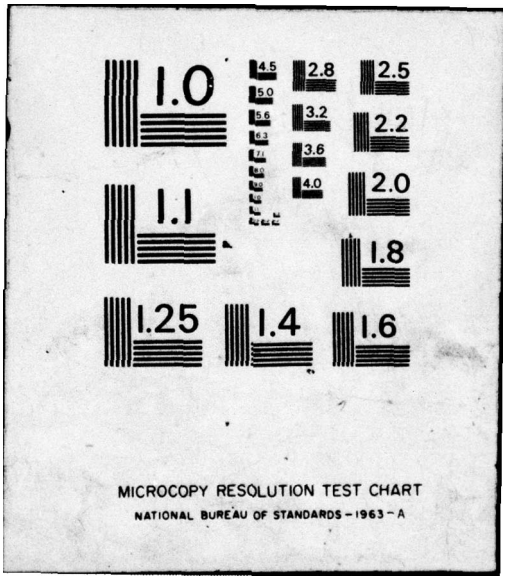
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS - 1963 - A

UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

STEBG-TD

29 JAN 1964

SUBJECT: Report of Test, USATECOM Project No. 4-4-0230-01, Military Potential Test of the S-64 Helicopter

TO: Commanding General
US Army Test and Evaluation Command
ATTN: AMSTE-BG
Aberdeen Proving Ground, Maryland 21005

1. References. A list of references is attached as inclosure 5.

2. Authority.

a. Directive. Letter, AMCRD-DM-A, US Army Materiel Command, 30 September 1963, subject: "Request for Letter Report," with 1st indorsement, AMSTE-BG, US Army Test and Evaluation Command, 4 October 1963.

b. Purpose.

The purpose of this document is

(1) To determine the military potential of the S-64 Helicopter configuration for use in the Army environment.

(2) To determine deficiencies and shortcomings in the S-64 requiring correction to enhance the military potential of the CH-54A Helicopters now on order.

3. Background.

a. Combat Development Objectives Guide (CDOG) subparagraph 533a(14), as amended 25 March 1963, states that a requirement exists for: "A heavy lift VTOL vehicle capable of transporting externally a 12-ton payload at sea level for a 20-mile radius of action. Operations will be conducted under visual conditions only. This item will be employed

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as a special means of transport of heavy equipment in tactical and logistical operations. Development and operation of this vehicle, subject to approval of the Secretary of Defense, will be in consonance with memorandum of the Secretary of Defense, 26 November 1956, subject: 'Clarification of Roles and Missions to Improve the Effectiveness of Operation of the Department of Defense.'"

b. Active US Army interest in a crane-type helicopter dates to 1953, when the first proposed military characteristics (MC's) were prepared by Board No. 1, Fort Bragg, North Carolina, and forwarded to Department of the Army. This action was followed by parametric studies completed in 1957, which concluded that it is feasible to produce flying crane helicopters to meet the CDOG requirement. In 1958, the US Army Aviation Test Board (USAAVNTBD) prepared MC's for a flying crane helicopter and forwarded the draft MC's to US Continental Army Command (USCONARC) on 14 November 1958.

c. In 1959, the US Army leased the S-60 Helicopter for an evaluation of the crane concept. This evaluation determined that the crane configuration was feasible, practical, and more versatile than conventional helicopter configurations.

d. The S-64 Helicopter was developed over a period of ten years as a result of studies and investigations made by the manufacturer to fulfill the Army's requirement for a flying crane (heavy-lift) helicopter. The design and development were funded entirely by the manufacturer. Three S-64 Helicopters were produced. Two were purchased by the Federal Republic of Germany and the third was retained by the manufacturer. On 28 June 1963, the US Army contracted for six CH-54A (S-64) Helicopters for further testing which includes Federal Aviation Agency (FAA) certification (provisional), concept evaluation, and service testing. Delivery schedule covers the period from June to December 1964.

e. In June 1963, USCONARC leased the company owned S-64 Helicopter from the manufacturer for approximately 70 calendar days and 60 flight hours. Initial flight testing (10 hours) was conducted during the period 26 June to 3 July 1963 by the 11th Air Assault Division (AAD). Subsequent flight testing (50 hours) was conducted during the period 20 September to 20 November 1963 by the 11th AAD and the USAAVNTBD.

4. Description of Materiel. A description of materiel is attached as inclosure 1.

5. Test Objectives. A military potential test was conducted to determine:

a. Physical characteristics.

b. Flight characteristics and performance.

c. Servicing and maintenance requirements.

d. Safety considerations.

6. Test Data. Test data and information furnished by the manufacturer are contained in inclosure 2.

7. Scope.

a. A joint test (50 flight hours) was conducted, consisting of a concept evaluation by the 11th AAD, Fort Benning, Georgia, and a military potential test by the USAAVNTBD, Fort Rucker, Alabama. The method and scope of the overall evaluation were determined by the 11th AAD, and the helicopter was utilized primarily for concept testing. The results of the military potential test were compared against the suitability for operation in the Army environment since approved MC's have not been published by Department of the Army.

b. The test helicopter has not been certificated by the FAA. Provisional certification is anticipated in June 1964. Because of this, flight testing was restricted to day visual flying conditions and to flights when the manufacturer's representative was performing duties as first pilot.

8. Findings.

a. The overall physical characteristics of the S-64 Helicopter were satisfactory for operation in the test (temperate) environment. Deficiencies and shortcomings noted during the test are listed in inclosure 3.

b. The crane configuration is suitable for:

(1) Transporting a variety of heavy bulky loads, such as bulldozers, pontoon bridge sections, vehicles, signal command center, pallets, and special purpose pods using a four-point suspension system.

(2) Retrieving and transporting loads with the single-point suspension system.

c. The flight characteristics and performance of the helicopter were satisfactory. Single engine performance was not determined.

d. The pressure-refueling capability was not tested due to lack of ground based pressure-refueling equipment. Refueling by gravity was unsatisfactory because of the large volume (approximately 9000 pounds) required and the low rate of flow of standard Army refueling equipment.

e. All maintenance during the conduct of this evaluation was accomplished by a factory team supplied and controlled by the manufacturer; therefore, maintenance requirements cannot be considered representative of the Army operations in the field.

f. Aviation safety aspects were considered in the overall design and construction of the S-64 Helicopter. However, deficiencies and shortcomings affecting safety were found to exist in areas pertaining to fire prevention, emergency jettison capability, and the design of certain systems to operate only from the No. 1 engine.

9. Discussion. The S-64 Helicopter, because of its heavy-lift capability and design features, is capable of transporting external loads and pods that other helicopters in the present inventory cannot transport because of gross weight limitations and design. Proposed changes (listed below) in the configuration and the elimination of deficiencies and shortcomings listed in inclosure 3 would enhance the flexibility, range, and overall efficiency of the six CH-54A Helicopters now on order.

a. Two hoist systems, single- and four-point suspension, were used for transporting loads.

(1) The four-point suspension system was considered to be superior. Greater speeds and maneuverability were possible because of fewer vibrations and oscillations. Limitations of the system, utilizing load levelers, were the limited vertical travel (16 inches when combined with the gear kneeling system) and the difficulty of load and pod pickup on rough terrain. The four load levelers should be replaced with selectively-controlled hydraulic winches which are provided with 50 feet of cable, improved load isolators, and possess a positive emergency jettison capability. Provisions for cockpit controls for normal release of the loads are necessary in production helicopters.

(2) The single-point suspension system with its 100 feet of cable allows a high hover over loads surrounded by trees or other obstacles, and subsequent winching of the load to the helicopter. This system is also ideally suited for towing, but this capability was not tested. The limitations of this system was the tendency of the loads to rotate and oscillate, necessitating a reduction of airspeeds. In addition, harmonic vibrations between the load and the airframe may be encountered under certain load conditions at specified cable lengths necessitating the use of a load isolator. Repeated difficulty with the load isolator prevented extensive testing at or near maximum gross weights. An improved load isolator should be incorporated to permit transport of maximum gross loads at all cable lengths. The system (which weights approximately 925 pounds) is permanently fixed to the helicopter. A quick attach/detach method is necessary to save this weight and add to the payload when the single-point system is not being used.

b. Three fuel cells (front, center, and auxiliary) with an approximate 9000-pound total capacity were included in the test configuration. Endurance of the test helicopter was 2 hours 45 minutes and the range was 250 nautical miles. Deletion of the auxiliary fuel cell from the six helicopters now on order would decrease the endurance to 1 hour 45 minutes and the range to 150 nautical miles. When the additional fuel supply provided by the auxiliary fuel cell is not required for a short mission, the weight penalty imposed by the installation of an auxiliary fuel cell is negligible. Future brush-fire operations and the present situation in Vietnam requires that many sorties be flown toward the accomplishment of one mission. The majority of the sorties are flown without the benefit of refueling sites due to enemy guerilla forces.

The auxiliary fuel cell should be incorporated in production models to provide greater range and flexibility of operation during the test phase and to meet requirements for operation in remote areas.

c. The overall design, gross weight, airframe configuration, and rearward facing pilot station of the S-64 Helicopter are ideally suited for transporting a variety of detachable, special-purpose pods which could be self-contained, such as surgical rooms, signal centers, maintenance and repair shops, and command posts. These special-purpose pods, depending on design, may be transported on either the four-point or single-point suspension systems with advantages of utilizing either system. The four-point system would permit more rapid deployment and the movement of a larger number of pods. The single-point system would permit pods to be lowered into confined areas, with natural or man-made obstacles, where landings are not otherwise possible. This airlift delivery of special-purpose pods would increase the flexibility and enhance the operation of tactical units operating in the Army environment.

d. The S-64 Helicopter, employing both methods of external attachment, was capable of transporting various types of palletized loads. The largest load (17,000 pounds) carried by pallet utilizing the four-point suspension system was the AN/MRC-54 Signal Relay Station complete with fuel (two 55 gallon drums), weapons, ammunition, and rations for three days for the crew. Load configuration and density had little effect upon aircraft controllability when using the four-point suspension system, provided proper center-of-gravity loading of the pallet was insured by ground personnel. The benefits derived from the four-point suspension system were increased airspeeds, maneuverability, and greater stability of aircraft and load. Lesser speeds and finer pilot control techniques were necessary when transporting pallets employing the single-point suspension system. However, the outstanding advantage of this latter system is its ability to pick up or deliver pallets into confined areas with natural or man-made obstacles, where landings are not otherwise possible.

e. The test helicopter had a 360-channel VHF transceiver, a 1750-channel UHF transceiver, and an Automatic Direction Finder (ADF). The proposed Army standard avionics electronic configuration, a VOR Radio AN/ARN-30D, and complete provisions for VHF Radio Set,

AN/ARC-73 should be included in the six production helicopters. The VOR Navigational Receiver is highly desirable for the many ferry flights programmed during the test period. The complete AN/ARC-73 Radio Set provisions would permit an evaluation of VHF provisions for possible future use by the CH-54A in an overseas employment and thereby eliminate expensive engineering change proposals (ECP's) or modification work orders (MWO's). In addition to the three C-1611/AIC headset outlets presently installed, two additional headset outlets are required in the cockpit for personnel use, and two external outlets are required for use by ground-handling personnel. Each external outlet should incorporate a spring type rewinding apparatus with a 100-foot extension cord.

10. Conclusions.

a. The S-64 Helicopter configuration possesses significant military potential for use in the Army environment.

b. The overall military potential of the CH-54A Helicopters now on order would be enhanced by the following:

(1) Correction of deficiencies and shortcomings listed in inclosure 3.

(2) Incorporation of the tested auxiliary fuel cell.

(3) Incorporation of improved load isolator in the single-point suspension system.

(4) Availability of ground based pressure-refueling systems.

(5) Availability of pallet(s) and special-purpose pod(s) for feasibility testing.

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11. Recommendations. It is recommended that:

a. The CH-54A Helicopter be considered suitable as an interim heavy-lift helicopter for Army use.

b. Suitable pallet(s) and special-purpose pod(s) be procured for concept and service testing.

c. The CH-54A Helicopter be further tested under temperate, desert, and high-altitude conditions after elimination of deficiencies and shortcomings listed in inclosure 3 and incorporation of the features listed in paragraph 10b above.

A. J. RANKIN
Colonel, Armor
President

5 Incl
1, 2, 3, 5 as
4, Army "T" Panel

DESCRIPTION OF MATERIEL

1. The S-64 Helicopter has a single, six-bladed, fully-articulated main rotor and a four-bladed, fully-articulated antitorque tail rotor. Power is supplied by two Pratt-Whitney JFTD-12A-1 free gas turbine engines (4050 shaft horsepower (s.hp.) each) mounted externally above the center fuselage section in a side-by-side configuration. The all-metal fuselage is composed of the forward, center, and after sections. The landing gear system is a tricycle type consisting of two fixed main gear assemblies and a full swiveling nose wheel. Each main gear assembly is equipped with a hydraulically operated kneeling (lowering) and a jacking (raising) system which permits the fuselage to be lowered eight inches to aid in load attachment/detachment.

2. The cockpit has three entrance doors--forward doors on the right and left side provide access to the pilot and copilot's seats, and a rear door provides access to the rearward facing pilot's seat and the two passenger seats. All positions are accessible from any door. Dual flight controls and instruments are provided for the pilot and copilot, and hoist controls and hover flight controls are provided for the rearward facing pilot. Automatic stabilization equipment (ASE) controls are provided at the three pilot positions.

3. The helicopter has three separate hydraulic systems: primary, secondary, and utility all of which are used for flight control operation. The utility system operates the jacking and kneeling systems, main wheel brakes, ASE, and two hoist systems. The hoist systems, single- and four-point suspension, are used for transporting pallets, pods, and external loads.

a. The single-point system (cargo hoist) is mounted directly under the main transmission and consists of a large revolving drum, 100 feet of 7/8-inch steel cable, a cargo hook, and a hydraulic load isolator. The cargo hoist is designed to support loads up to 20,000 pounds; however, the hydraulic load isolator is restricted to approximately 15,000 pounds.

b. The four-point system utilizing load levelers is mounted on each side of the airframe fore and aft of the main transmission and consists of four hard points each having a roller, 20 feet of cable (15 feet usable). The levelers may be operated individually or collectively for a maximum of eight inches of vertical travel at each point.

Incl 1

4. The following weights and dimensions were obtained from the manufacturer's flight manual or representative.

a. Airframe dimensions:

Length	Maximum, main rotor blades extended	88 ft. 0 in.
	Minimum, main rotor blades folded	77 ft. 2 in.
Width	Maximum, main rotor blades extended	72 ft. 0 in.
	Minimum, main rotor blades folded	21 ft. 10 in.
	Main rotor diameter	72 ft. 0 in.
	Tail rotor diameter	15 ft. 8 in.
	Main landing gear tread	19 ft. 9 in.
Height	Maximum, tail rotor tip	24 ft. 11 in.
	Main rotor minimum ground clearance	18 ft. 7 in.
	Tail rotor minimum ground clearance	9 ft. 2 in.

b. Pod dimensions (inside):

Length	34 ft. 9 in.
Width	6 ft. 5 in.
Height	11 ft. 6 in.

c. Weights:

Basic operating weight	19,922 lb.
Maximum gross weight	38,000 lb.
Useful load (at maximum gross weight)	18,078 lb.
Pod (empty)	2,994 lb.
Pod (with seats, ramps and soundproofing)	3,946 lb.

TEST DATA AND INFORMATION

FURNISHED BY THE MANUFACTURER

1. Scope of Tests.

a. The S-64 Helicopter was tested for approximately 50 flight hours by personnel of the 11th Air Assualt Division (AAD) in conjunction with the US Army Aviation Test Board (USAAVNTBD). Testing was conducted at Fort Stewart, Georgia, during exercise "Sky Soldier (Phase II)" from 28 September to 15 October 1963, and at Fort Benning, Georgia, from 16 October to 20 November 1963. Three pilots from the 11th AAD and one pilot from the USAAVNTBD operated the helicopter from the copilot position and also from the rearward-facing pilot position.

b. The four-point and single-point suspension systems were tested. The following loads were transported on a pallet, through direct attachment, or inside the pod.

Description	Approximate Weight (Lb.)	Suspension System
HD-6 Bulldozer	16,000	Four point
Roller, towed, pneumatic tired	14,000	Four point
500 gal. sealed bin container (4)	12,000	Pod (four point)
500 gal. sealed bin container (4)	12,000	Four point
500 gal. sealed bin container (4)	12,000	Single point
MHE-164 Forklift	17,300	Four point
M-35 2 1/2 ton truck with winch	12,800	Four point
M-35 2 1/2 ton truck without winch	12,300	Single point
UH-1D Helicopter (damaged)	5,000(Est.)	Single point
M-38A1 1/4 ton truck (3)	7,500	Pod (four point)

Incl 2

Description	Approximate Weight (Lb.)	Suspension System
M-38A1 1/4 ton truck (2) loaded on pallet	6,400	Single point
M-56 (Scorpion), self-propelled 90mm anti-tank weapon	13,000	Four point
M4T6 engineer pontoon bridge single section (complete)	11,700	Four point
M4T6 engineer pontoon bridge double section (incomplete) (hover flight only)	16,186	Four point
AN/MRC-54 Signal Relay Station loaded on pallet	17,000	Four point

2. Details of Test.

a. Physical Characteristics.

(1) Weights and Dimensions. Visual inspection of the test helicopter and weight computations made during the test period appeared to corroborate data furnished by the manufacturer (see paragraph 4 of inclosure 1).

(2) Cockpit Configuration. A detailed evaluation of the cockpit was not attempted since this experimental helicopter was not representative of the Army version (CH-54A); however, the following were noted:

(a) The flight instruments were not arranged in accordance with the approved Army "T" panel configuration (inclosure 4).

(b) The circuit breaker panel was not within reach of the pilot or copilot.

(c) The pilot's and copilot's seats were adjustable up, down, fore, and aft. The seats were uncomfortable for some personnel because the forward and rearward travel did not permit sufficient range of adjustment.

(d) Conventional toe brakes, which react on the main landing gear wheels, were available on the pilot's antitorque pedals. No provisions for brakes were made on the copilot's side. The pilot and copilot experienced difficulty with their feet slipping off the antitorque pedals.

(e) The cargo release switch for emergency operation of the single-point suspension system is located on the upper right side of the pilot's and copilot's cyclic stick and the rearward facing pilot's hover stick. A positive emergency means was not provided for jettisoning loads when utilizing the four-point suspension system.

(f) Provisions for standard Army helicopter avionics configuration were adequate except for lack of tactical radios (HF/SSB and FM) and OMNI (VOR) receiver.

(3) Four-Point Suspension System. The four-point suspension system was preferred over the single-point system. Greater speeds and maneuverability of the helicopter were possible when transporting loads utilizing this system because of load stability, fewer vibrations, and oscillations; however, this system utilizing load levelers has only eight inches of vertical travel (16 inches when combined with gear kneeling system). The load levelers operated satisfactorily on level terrain and hardstand; however, on rough terrain, loads could not be lifted free of the ground due to insufficient vertical travel of combined load leveling and kneeling system. Pod attachment and detachment were virtually impossible unless operating from level terrain. The pod attaching/detaching operation required five specially trained men, one for each hard point and one in the cockpit, and required excessive time (1 1/2 hours for attachment to 4 1/2 minutes for detachment).

(4) Single-Point Suspension System (cargo hoist).

(a) The single-point suspension system was satisfactory; however, it was inferior to the four-point suspension system. Harmonic vibrations between the load and airframe under certain load conditions and cable lengths required the use of a load isolator, and the loads had a tendency to rotate and oscillate. With one load (damaged UH-1D) extreme lateral pendulum-like oscillations were encountered resulting in control problems which necessitated reducing airspeed. Repeated difficulty with the load isolator prevented extensive testing of this system.

(b) Two types of cargo hooks were tested. The first weighed approximately 85 pounds, was closed by means of two meshing jaws, and required approximately 4 seconds to release. The second weighed approximately 45 pounds, was a positive-lock, mine towing type, and had an instantaneous release. The second type was superior because it weighed less, had a positive lock, a less complex electrical system, and an instantaneous release feature.

(c) One important feature observed was the lack of static electricity when handling the cargo hook.

(5) Landing Gear System. The landing gear functioned satisfactorily; however, the nose gear locking pin was weak and sheared with a slight amount of lateral force.

(6) Auxiliary Power Plant (APP). The first 45 hours of the evaluation were trouble free. In the remaining five hours, difficulty was experienced in starting the APP. A back-up system is programmed for the six helicopters now on order.

b. Flight Characteristics and Performance. Flight characteristics and performance of the helicopter were satisfactory. Power requirements at maximum gross weights under test conditions never exceeded approximately 70 percent (5400 s.hp.) of the total available (8100 s.hp.). Single-engine performance was not determined because of company insurance limitations; however, in view of the above, it is anticipated that the S-64 has the capability of single-engine operation under emergency conditions.

c. Servicing and Maintenance Requirements.

(1) During the evaluation, the helicopter was maintained by the manufacturer's representatives with military personnel providing servicing and general assistance.

(2) Engine operation was satisfactory on standard Army fuel (JP-4) and lubricants. JP-1 and JP-5 fuels were also used during ferry missions with satisfactory results.

(3) Fuel consumption was 3000-3400 pounds per hour and refueling was a continuous problem. Three fuel cells (front, center, and auxiliary) each with an approximate 3000-pound capacity and a pressure-refueling system are included in the present configuration

(auxiliary tanks are not programmed for helicopters now on order). Ground based pressure-refueling systems were not available, and the refueling operation utilizing the standard M-49 was unsatisfactory.

(4) The helicopter was easy to service and maintain. All major components were readily accessible except the tail pylon, tail rotor, and bottom of fuselage. An engine change was accomplished during the evaluation, and replacement required approximately 60 man-hours.

(5) Tools and ground support equipment normally found at the organization level were adequate for organizational maintenance. Special tools are required for higher echelons of maintenance.

(6) Lack of sheet metal problems contributed to the ease of maintenance.

d. Safety Considerations. The following were noted during the evaluation:

(1) Lack of fire barrier or cowling between the engines and between the engines and transmission.

(2) Lack of a positive instantaneous jettison capability when utilizing the four-point suspension system.

(3) Lack of protective covers for exposed control rods and lines on transmission deck.

(4) Lack of alternate provisions for converting a.c. to d.c. power for flight instruments after failure of No. 1 transformer rectifier and either generator.

(5) Lack of provisions for flight control servo operation from No. 2 engine.

(6) Lack of copilot brakes.

(7) Close proximity of front filler cap to No. 1 engine exhaust and center filler cap to main rotor brake, which develops very high temperatures on shutdown.

(8) Lack of guards for switches located on center console between pilot and copilot.

(9) Lack of guard for rearward facing pilot's collective control.

DEFICIENCIES, SHORTCOMINGS,

AND SUGGESTED CORRECTIVE ACTION

1. The following deficiencies were noted during the evaluation:

Deficiency	Suggested Corrective Action
a. Brakes were not provided for copilot.	Provide brakes for copilot.
b. The cargo release switch for the single-point suspension system cannot be activated without moving from the normal hand grip position.	Install proposed utility/cargo stick grip (reference 8).
c. A positive, emergency jettison capability for the four-point suspension system was not incorporated.	Redesign system to incorporate a positive, instantaneous jettison capability.
d. HF/SSB and FM tactical radios and Omni (VOR) receiver were not included.	Incorporate proposed standard Army avionic configuration to include VOR receiver and complete provisions for VHF radio AN/ARC-73.
e. Load levelers have insufficient usable cable (15 feet) and limited vertical travel (8 inches).	Replace load levelers with selectivity-controlled hydraulic winches, each with 50 feet of cable, load isolators, and cockpit controls for normal release of loads.
f. Pod attachment/detachment was virtually impossible on rough terrain.	Redesign pod attachment system allowing for a quick attachment/detachment (maximum 3 minutes).
g. Single-point suspension system without load isolator was unsuitable for transporting maximum gross loads due to harmonic vibrations between load and airframe.	Provide improved load isolator with the single-point suspension system.

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Deficiency	Suggested Corrective Action
h. Nose gear locking pin is weak and shears with slight amount of lateral force.	Redesign nose gear locking system.
i. Fire barrier or cowling between engines and between engines and transmission were not provided.	Provide barriers.
j. Protective covers for exposed control rods and various type lines on transmission deck were not provided.	Provide protective covers and/or personnel walkways.
k. Alternate provisions for converting a.c. to d.c. power for flight instruments after failure of No. 1 transformer rectifier (T/R) and either generator were not incorporated.	Redesign electrical system to use either T/R alternately, as required.
l. Provisions for flight control servo operation from No. 2 engine were not included.	Provide flight control servo operation from both engines.
m. Close proximity of front filler cap to No. 1 engine exhaust and center filler cap to main rotor brake is a fire hazard.	Relocate filler caps.
n. Guards for switches located on center console between pilot and copilot were not provided.	Provide guards.
o. Guard for rearward facing pilot's collective control was not provided.	Provide guard.
p. Single-point suspension system weighed 925 pounds and could not be detached.	Provide a quick-disconnect and a means of lifting the system back into position for attachment.

Deficiency	Suggested Corrective Action
q. Cargo hook did not have instantaneous release.	Provide a cargo hook with an instantaneous release feature.

2. The following shortcomings were noted during the evaluation:

Shortcoming	Suggested Corrective Action
a. Instrument panel was not arranged in accordance with approved Army "T" configuration.	Change instrument panel to conform to approved Army "T" Panel (inclosure 4).
b. Location of circuit breaker panel was not within reach of pilot or copilot.	Relocate circuit panel within reach of pilot or copilot.
c. Fore and aft travel for adjustment of pilot's and copilot's seats was insufficient.	Increase fore and aft seat travel.
d. Pilot and copilot experienced difficulty with feet slipping off antitorque pedals.	Redesign pedals.

ARMY INSTRUMENT "T" PANEL

1. Basic Panel Arrangement.

a. In order to arrive at an optimum instrument panel arrangement, consideration had to be given to the following factors:

(1) First, the instruments had to be arranged so as to give those of primary use and importance the central or most easily and naturally seen positions, while grouping the other instruments functionally and compatibly around them in order of priority.

(2) Second, the "basic six" instruments had to be grouped so that they provided a natural representation of the parameter indicated.

(3) Third, the arrangement had to be compatible with approved arrangements of integrated instrument displays in order to allow safe and orderly transition from one display to the other.

b. It can easily be seen from inclosures 1 and 2 that the "T" arrangement accomplishes each of the objectives outlined above.

(1) The attitude indicator - the instrument of primary importance - is given the central location while the heading indicator, being considered second in importance, appears immediately below the attitude indicator. The primary supporting instruments with regard to pitch attitude are placed on either side of the attitude indicator, while the secondary instrument in pitch is provided immediately below the altimeter. The turn and bank indicator has been relegated to a position secondary to the RMI since the turn and bank indicator is considered a standby instrument in event of failure of the attitude indicator.

(2) The second objective is also accomplished since all primary pitch indications are about the horizontal (pitch) axis of the "T" whereas all roll or yaw indications are about the stem (yaw) axis of the "T".

(3) The third objective is accomplished merely by replacing the three-inch attitude and heading indicators with a four-inch approach horizon and a plan situation display respectively. This allows the same information to be obtained from the same relative locations, thus eliminating time and confusion factors during transition from one display to the other.

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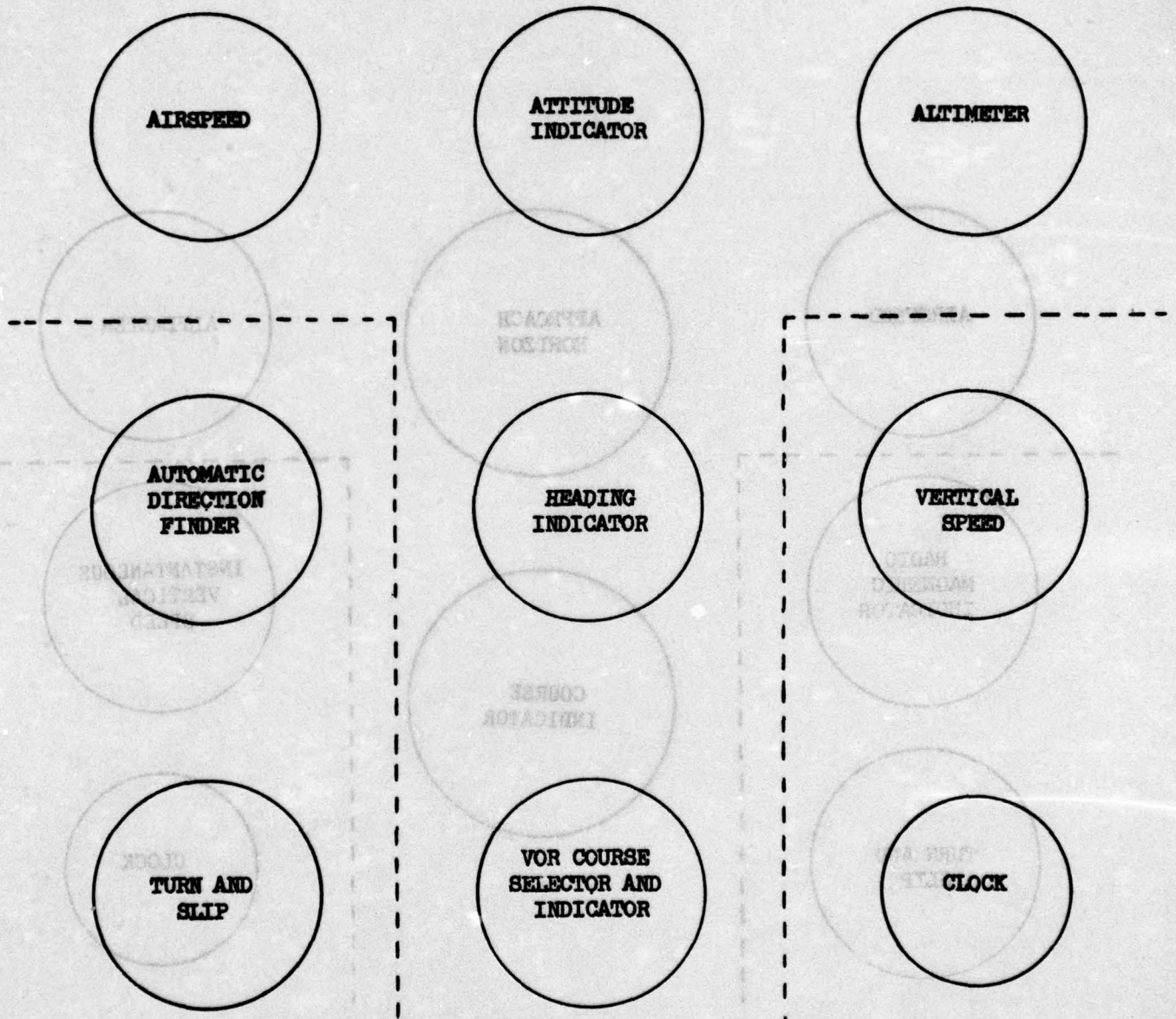
2. Instruments Currently Standard in the Army System. During tests, the optimum panel arrangement of instruments currently standard in the Army system was determined. Aviators with varying and more than average amounts of instrument experience flew under actual and simulated instrument conditions, using various panel arrangements. After a combined total of more than 500 hours of actual and simulated instrument flight, these aviators were unanimous in their choice of the "T" panel arrangement as presented in inclosure 1.

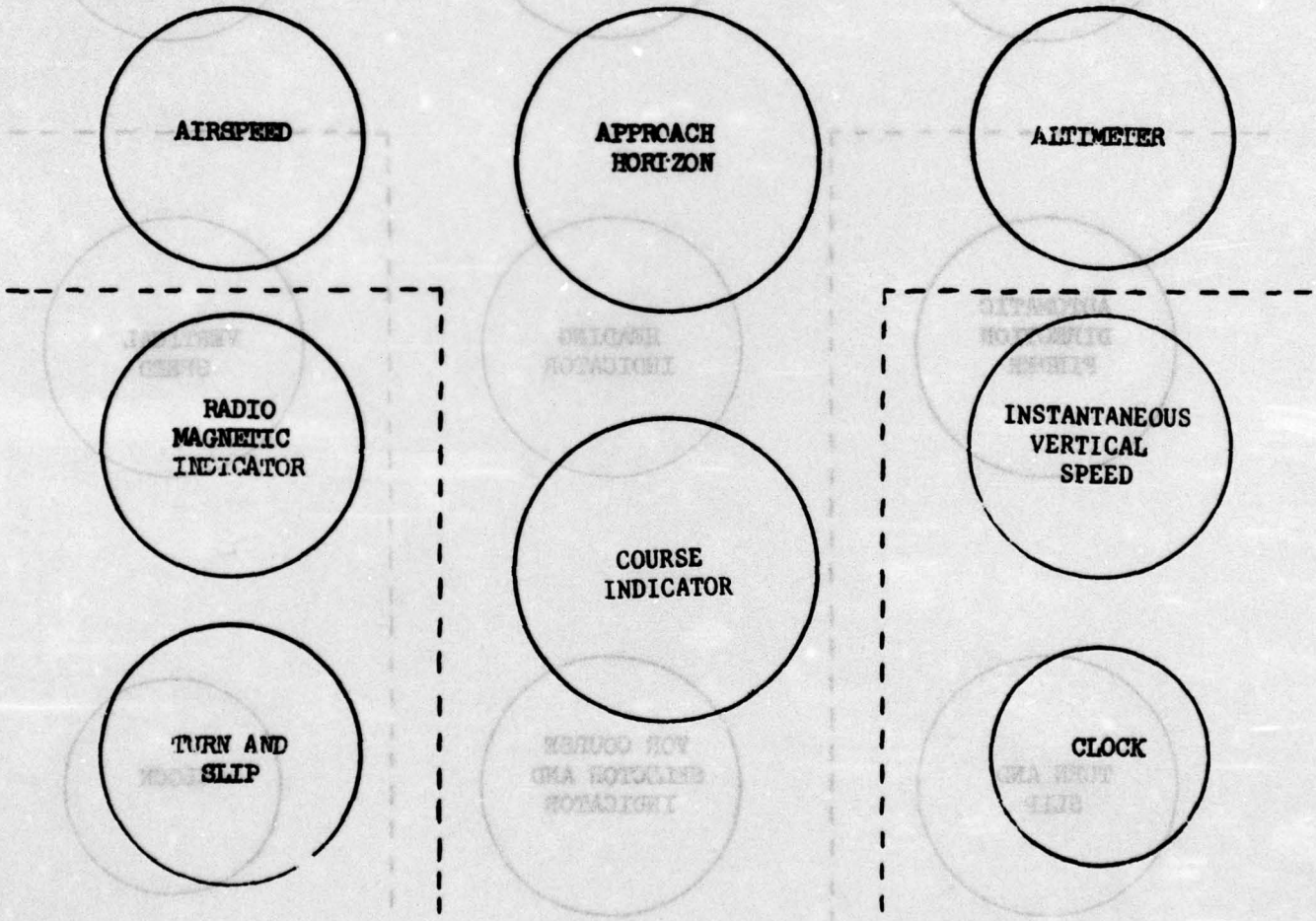
3. Integrated Instrument Systems. The integrated instrument systems available to this Board (Collins Integrated Flight Systems FD-103C and FD-105, Sperry Integrated Instrument System, and Lear Integrated Flight Equipment) were flown by experienced instrument-qualified aviators more than 1000 hours under actual and simulated instrument conditions. The Collins, Sperry, and Lear systems were installed in, and found to be compatible with, the basic "T" arrangement; however, the course indicators which combined VOR information with primary heading in the basic "T" arrangement were more compatible than the one which presented heading on a separate instrument. The optimum panel arrangement utilizing integrated instruments as determined during these tests is attached as inclosure 2.



Optimum Panel Arrangement of Instruments Currently Standard in the Army

(Dotted line indicates basic "T," not to be painted on panel)

Incl 1 to incl 4



Optimum Panel Arrangement for Integrated Systems

(Dotted line indicates basic "T," not to be painted on panel

Incl 2 to incl 4

LIST OF REFERENCES

1. Combat Developments Objectives Guide (CDOG) subparagraph 533a(14), 25 March 1963.

2. Letter, ATDEV-6 452.1, Headquarters, US Continental Army Command, 14 November 1958, subject: "Military Characteristics for Flying Crane Vehicle."

3. First Interim Report, "Summary of Parametric Studies of Flying Crane Helicopter," US Army Transportation Research Command, Project No. 9-38-04-000, August 1957.

4. Report of Test, "Report of Evaluation of the S-60 Flying Crane," US Army Aviation Center, 17 December 1959.

5. Report of Test, Project Nr. AVN 1860, "S-60 Crane Concept Evaluation," US Army Aviation Board, 30 October 1959.

6. Message, Department of the Army, DE RUEPDA, Unclassified No. DA 937044, dated 18 September 1963.

7. Letter, AJIMT-O&M, Critical Material Branch, Organization and Material Division, Test, Evaluation and Control Group Project Team, subject: "CH-54 Flying Crane Evaluation Conference," dated 28 September 1963, with 1 inclosure, Plan of Evaluation.

8. Report of Test, USATECOM Project No. 4-3-5300-01-A, "Military Potential Test of the Helicopter Stick Grip," US Army Aviation Test Board, 18 December 1963.

9. Manufacturer's Flight Manual, Model S-64A.

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